Accepted author's manuscript. Published in final edited form as: JACC Cardiovascular Interventions 2021 (in press). Publisher DOI: 10.1016/j.jcin.2021.01.042

AGE-RELATED OUTCOMES AFTER TRANSCATHETER AORTIC VALVE REPLACEMENT: INSIGHTS FROM THE SWISSTAVI REGISTRY

Adrian Attinger-Toller MD[1]§, Enrico Ferrari MD[2]§, David Tueller MD[3], Christian Templin MD[4], Olivier Muller MD[5], Fabian Nietlispach MD PhD[6], Stefan Toggweiler MD[7], Stéphane Noble MD[8], Marco Roffi MD[8], Raban Jeger MD[9], Christoph Huber MD[10], Thierry Carrel MD[11], Thomas Pilgrim MD MSc[12], Peter Wenaweser MD[13], Mario Togni MD[1,15], Stéphane Cook MD[1,15], Dik Heg PhD[14], Stephan Windecker MD[12], Jean-Jacques Goy MD[1,15 *] and Stefan Stortecky MD[12*]

Adrian.Attinger@bluewin.ch; Enrico.Ferrari@cardiocentro.org; David.Tueller@triemli.zuerich.ch; Christian.Templin@usz.ch; Olivier.Muller@chuv.ch; fabian.nietlispach@hirslanden.ch; stefan.toggweiler@luks.ch; Stephane.Noble@hcuge.ch; marco.roffi@hcuge.ch; Raban.Jeger@usb.ch; Christoph.Huber@hcuge.ch; Thierry.Carrel@insel.ch; thomas.pilgrim@insel.ch; PeterMartin.Wenaweser@hirslanden.ch, mario.togni@unifr.ch; stephane.cook@unifr.ch; dierik.heg@ctu.unibe.ch; Stephan.Windecker@insel.ch; jjgoy@goyman.com;; Stefan.Stortecky@insel.ch

[1]Department of Cardiology, University and Hospital Fribourg, Fribourg, Switzerland
[2]Department of Cardiac Surgery, Cardiocentro Ticino, Lugano, Switzerland and the University Heart Center, Zurich, Switzerland
[3]Department of Cardiology, Triemli Hospital Zurich, Zurich, Switzerland
[4]Department of Cardiology, University Heart Center, Zurich, Switzerland
[5]Department of Cardiology, Lausanne University Hospital, Lausanne, Switzerland
[6]Cardiovascular Center Zurich, Hirslanden Klinik Im Park, Zurich, Switzerland
[7]Department of Cardiology, Cantonal Hospital, Luzern, Switzerland
[8]Department of Cardiology, Geneva University Hospital, Geneva, Switzerland
[9]Department of Cardiology, Basel University Hospital, University of Basel, Basel, Switzerland
[10]Department of Cardiovascular Surgery, Geneva University Hospital, Geneva, Switzerland
[11]Department of Cardiovascular Surgery, Inselspital, Bern University Hospital, Bern, Switzerland
[12]Department of Cardiology, Inselspital, Bern University Hospital, Bern, Switzerland
[13]Department of Cardiology, Heart Clinic Hirslanden Zurich, Switzerland
[14]CTU Bern, University of Bern, Bern, Switzerland
[15]Department of Cardiology, Hirslanden Clinique Cecil, Lausanne, Switzerland

§ Drs. Attinger-Toller and Ferrari contributed equally to this manuscript.
** Drs. Stortecky and Goy contributed equally to this manuscript.*

Brief title: Age and Outcomes after TAVR

Twitter: @StefanStortecky: Analysis from @SwissTAVI – Age is associated with a linear trend for mortality, stroke and pacemaker implantation after TAVR.

Funding: The SwissTAVI Registry is supported by a study grant from the Swiss Heart Foundation and the Swiss Working Group of Interventional Cardiology and Acute Coronary Syndromes, and is sponsored by research grants from Medtronic, Edwards Lifesciences, Boston Scientific and Abbott. The study sponsors had no role in study design, data collection, data analysis, data interpretation, or writing of the manuscript.

Conflict of interest statement:
S. Stortecky has received research grants to the institution from Edwards Lifesciences, Medtronic, Abbott Vascular and Boston Scientific, serves as consultant for BTG and Teleflex and has received speaker fees from BTG and Boston Scientific. C. Templin reports receiving fees outside the submitted work for serving on advisory boards from Astra Zeneca and Amgen; serving as a consultant for Schnell Medical and Shockwave; travel support from Abbott Vascular, Biosensors, Boston Scientific, Edwards Lifesciences, and Medtronic; and research grant support from Abbott Vascular. S. Toggweiler serves as a consultant and proctor for Boston Scientific, Biosensors / New Valve Technology, as a proctor for Abbott Vascular, as a consultant for Carag, has received speaker honoraria from Medtronic and is a board member of and holds equity in Hi-D Imaging. D. Heg is affiliated with CTU Bern, University of Bern, which has a staff policy of not accepting honoraria or consultancy fees. However, CTU Bern is involved in design, conduct, or analysis of clinical studies funded by not-for-profit and for-profit organizations. In particular, pharmaceutical and medical device companies provide direct funding to some of these studies. For an up-to-date list of CTU Bern's conflicts of interest see http://www.ctu.unibe.ch/research/declaration_of_interest/index_eng.html. T. Pilgrim has received research grants to the institution from Biotronik and Boston Scientific, speaker fees from Boston Scientific and Biotronik and consultancy for HighLife SAS. O. Muller serves as consultant for Abbott and received speaker fees from Edwards Lifesciences. E. Ferrari is a proctor and consultant for Edwards Lifesciences. C. Huber was a proctor for Edwards Lifesciences and Boston Scientific / Symetis. R. Jeger has received institutional research grants from B. Braun Melsungen AG and received speakers honoraria from B. Braun Melsungen AG, Cardionovum and Nipro. M. Roffi has received institutional research grants from Boston Scientific, Biotronik, Terumo, Medtronic and GE Healthcare. D. Tüller received speaker fees from Edwards Lifesciences, Boston Scientific and received reimbursement for travel expenses from Edwards Lifesciences, Boston Scientific and Medtronic. F. Nietlispach has served as consultant for Abbott, Edwards Lifesciences and Medtronic. P. Wenaweser is a proctor for Edwards Lifesciences and Medtronic and has served as consultant for Edwards Lifesciences, Medtronic and Cardinal Health (fellow training). Stephan Windecker reports research and educational grants to the institution from Abbott, Amgen, BMS, Bayer, Boston Scientific, Biotronik, Cardinal Health, CardioValve, CSL Behring, Daiichi Sankyo, Edwards Lifesciences, Johnson&Johnson, Medtronic, Querbet, Polares, Sanofi, Terumo, Sinomed. Stephan Windecker serves as unpaid member of the steering / executive group of trials funded by Abbott, Abiomed, Amgen, BMS, Boston Scientific, Biotronik, Cardiovalve, Edwards Lifesciences, MedAlliance, Medtronic, Polares, Sinomed, V-Wave and Xeltis, but has not received personal payments by any pharmaceutical company or device manufacturer. He is also member of the steering / executive committee group of several investigated-initiated trials that receive funding by industry without impact on his personal remuneration.

Word count: 3205 words

Address for correspondence:
Adrian Attinger-Toller, MD
University and Hospital Fribourg
Telephone +41 41 205 60 65
Electronic address: adrian.attinger@bluewin.ch

ABSTRACT

Introduction Transcatheter aortic valve replacement (TAVR) is the preferred treatment for elderly patients with severe aortic stenosis and is expanding into lower age groups. We investigated age-related outcomes of patients undergoing TAVR as assessed in a nationwide, prospective, multicenter cohort study.

Methods We analyzed data from the SwissTAVI Registry. Clinical outcomes were compared between patients aged 70years or younger (n=324), 70-79years (n=1913), 80-89years (n=4353) and older than 90years (n=507). Observed deaths were correlated with expected deaths in the general Swiss population using standardized mortality ratios (SMR).

Results Between 02/2011 and 06/2018, 7097 patients (age 82.0±6.4years, 49.6%females) underwent TAVR at 15 hospitals in Switzerland. Procedural characteristics were similar; however, older patients more often had discharge to the referring hospital or a rehabilitation facility after TAVR. Using adjusted analyses, a linear trend for mortality (30-day HR_{adj} 1.45; 95%CI 1.18-1.77; 1-year HR_{adj} 1.12; 95%CI 1.01-1.24), cerebrovascular accidents (30-day HR_{adj} 1.35; 95%CI 1.09-1.66; 1-year HR_{adj} 1.21; 95%CI 1.02-1.45) and pacemaker implantation (30-day HR_{adj} 1.23; 95%CI 1.12-1.34; 1-year HR_{adj} 1.19; 95%CI 1.09-1.30) was observed with increasing age. Furthermore, SMRs were 12.63(95%CI 9.06-17.58), 4.09(3.56-4.74), 1.63(1.50-1.78) and 0.93(0.76-1.14) for TAVR patients in relation to the Swiss population <70, 70-79, 80-89 and ≥90 years of age, respectively.

Conclusions Increasing age is associated with a linear trend for mortality, stroke and pacemaker implantation during early and longer-term follow-up after TAVR. Standardized mortality ratios were higher for TAVR patients below the age of 90 years when compared to expected rates of mortality in an age- and sex-matched Swiss population.

ClinicalTrials.gov registration number NCT013682

CONDENSED ABSTRACT

SwissTAVI patients were analyzed according to four age groups (70 years or younger, 70-79 years, 80-89 years, and older than 90 years). Increasing rates and a linear trend for mortality (1-year HR_{adj} 1.12; 95%CI 1.01-1.24), cerebrovascular events (1-year HR_{adj} 1.21; 95%CI 1.02-1.45) and pacemaker implantation (1-year HR_{adj} 1.19; 95%CI 1.09-1.30) were observed with increasing age. Furthermore, SMRs were 12.63 (95%CI 9.06-17.58), 4.09 (95%CI 3.56-4.74), 1.63 (1.50-1.78) and 0.93 (0.76-1.14) for TAVR patients when compared with an age- and sex-matched Swiss general population.

KEY WORDS:

Aortic stenosis, transcatheter aortic valve replacement, age

ABBREVIATIONS AND ACRONYMS

AS	Aortic stenosis
CE	Conformité Européenne
CI	Confidence interval
EF	Ejection fraction
HR	Hazard ratio
NYHA	New York Heart Association
QOL	Quality of life
SMR	Standardized mortality ratios
STS-PROM	Society of Thoracic Surgeons, predicted risk of mortality
TAVR	transcatheter aortic valve replacement
VARC	Valve Academic Research Consortium

INTRODUCTION

The prevalence of degenerative aortic valve stenosis and age follows an exponential curve in the general population. While the prevalence of aortic stenosis amounts to 0.2% in the group 50-59 years of age, it rises to 1.3% in the group 60-69 years, 3.9% in the group 70-79 years and 9.8% in 80-89 year old individuals.(1) Based on demographic changes, a continuous increase has been noted worldwide in nonagenarians from 6.424 million people in 1995 to 21.387 million people in 2020,(2) and numbers will continue to rise with an estimated 76.706 million people aged 90 years or older in 2050.(3)

Transcatheter aortic valve replacement (TAVR) has emerged as the preferred treatment modality for a broad spectrum of elderly patients with symptomatic, severe aortic stenosis. (4,5) Advanced age itself is a driving factor during Heart Team discussions, and elderly patients are likely to be referred for a less-invasive TAVR intervention. However, the available literature provides conflicting evidence with regards to the clinical benefit of TAVR in the very elderly patient population. While results from single center studies and the national France-2 Registry suggest similar outcomes for octogenarians and nonagenarians at 30-day and 1-year follow-up,(6-8) the STS / ACC TVT Registry reported higher rates of 30-day and 1-year mortality in nonagenarians.(9)

Therefore, the purpose of the present study was to investigate the potential association between age and clinical outcomes after TAVR using data from the prospective SwissTAVI Registry.

METHODS

Design and setting

The SwissTAVI Registry (registered at clinicaltrials.gov with **NCT01368250**) is a national, prospective cohort study and was initiated by the Swiss Working Group of Interventional Cardiology and the Swiss Society of Cardiac and Thoracic Vascular Surgery in 2011. Details of the rationale and design of SwissTAVI have been previously described.(5,10) The SwissTAVI Registry is mandated by the Swiss Federal Office of Public Health (FOPH) to include all consecutive patients undergoing TAVR at approved sites in Switzerland.

Patient population and TAVR procedures

Patients from 15 heart valve centers in Switzerland were enrolled into the SwissTAVI Registry and prospectively followed according to a prospective protocol. Participating centers are listed in the online Appendix. Only patients treated with CE-approved TAVR devices were considered eligible for study inclusion. Device and access site selection was left at the discretion of the TAVR operators and was based on clinical and anatomical characteristics. For the purpose of this study four different age groups were created: patients below (<) 70 years of age, patients between the age to 70 and 79, patients between 80 and 89 years of age and patients equal or above (≥) the age of 90.

Data collection and follow-up

A web-based database (www.swisstavi.ch) with standardized case-report forms is used for data collection. Data monitoring, consistency checks and independent statistical analysis is provided by a Clinical Trials Unit (CTU Bern). Clinical events occurring during the procedure or follow-up were blinded for patient details and the performing heart valve center and adjudicated following review of original source documents by a dedicated clinical event

committee according to the updated standardized endpoint criteria proposed by the Valve Academic Research Consortium (VARC-2).(11) The SwissTAVI Registry protocol was approved by the local ethics committee at each participating center, and all patients provided written informed consent. The registry is performed under the lead of the Swiss Cardiovascular Center Bern at Bern University Hospital in cooperation with the Clinical Trials Unit Bern.

Study endpoints

The primary study endpoint was all-cause mortality at 1-year follow-up. Secondary outcomes included peri-procedural mortality, cardiovascular mortality, cerebrovascular accidents (composite of disabling / non-disabling stroke and TIA), myocardial infarction, bleeding complications, vascular or access-related complications and acute kidney injury. Serious adverse events were site reported and checked for plausibility. In addition, SMRs were calculated to compare trends in mortality of TAVR patients with an age- and sex-matched general population during the respective year of treatment (downloaded from the Swiss Federal Office for Statistics - Bundesamt für Statistik, Switzerland).

Statistical analysis

Baseline, procedural and in-hospital characteristics are presented as means ± standard deviation (SD) or counts (%); and tested with analysis of variance (ANOVA) or chi-square tests; comparing across the age groups. Clinical outcomes in-hospital are first events per event type (% from lifetable estimate) and analyzed with robustified Poisson regressions testing for a linear trend across the age groups. Clinical outcomes at 30 days and 1 year are first events per event type (percentage (%) from lifetable estimates, censoring patients at last valid contact date) and analyzed with Cox's regressions testing for a linear trend across the age groups. Adjusted rate or hazard ratios are presented after correcting for STS PROM score, femoral

access vs. other access and year of procedure. By matching patients on age, sex and year of TAVR with the corresponding mortality rates provided by the Swiss Federal Office for Statistics (Bundesamt für Statistik, Switzerland), SMRs were calculated. SMRs represent the number of observed deaths with respect to the expected deaths in the general Swiss population.(12) Statistical analyses were performed using Stata 15.1 (College Station, TX: StataCorp LP). Statistical significance was considered at $p < 0.05$.

RESULTS

Between February 2011 and June 2018, 7097 patients underwent TAVR. Mean age was 82.0 ± 6.4 years and 49.6% were female. Among patients, 324 (4.6%) were younger than 70 years of age, 1913 (27.0%) were between 70 and 79 years, 4353 (61.3%) were between 80 and 89 years, and 507 patients (7.1%) were older than 90 years of age. The more advanced the age, the more likely the patients were female, and less likely to have diabetes, dyslipidemia, peripheral artery disease, chronic obstructive pulmonary disease and a clinical history of myocardial infarction and previous cardiac surgery. Moreover, elderly patients were more symptomatic with more than two-thirds of nonagenarians in NYHA functional class III and IV on admission. Baseline clinical characteristics according to the study groups are detailed in **Table 1**.

Procedural information is provided in **Table 2**. The majority of patients underwent transfemoral TAVR with a significant trend for access site according to age. Elderly patients were more likely to have transfemoral TAVR compared with their younger counterparts. Details on the in-hospital course after TAVR are provided in **Table 3**. Significant differences between age groups were found for the total number of packed red blood cells administered

and the overall length of hospital stay. Moreover, elderly patients were less likely to be discharged home after intervention.

Table 4 summarizes clinical outcomes at 30 days and 1-year follow-up after TAVR. After 30 days, rates of all-cause and cardiovascular mortality followed a linear trend (HR_{adj} 1.45; 95%CI 1.18-1.77 and HR_{adj} 1.53; 95%CI 1.23-1.91, respectively) for increasing age. Similarly, rates of cerebrovascular events and permanent pacemaker implantation followed an increased risk across increasing age groups (HR_{adj} 1.35; 95%CI 1.09-1.66 and HR_{adj} 1.23; 95%CI 1.12-1.34, respectively). In contrast, an inverse correlation was found between Stage 3 kidney injury and age with higher event rates in the younger patient population (HR_{adj} 0.60; 95%CI 0.46-0.78). In landmark analyses, the risk of mortality was higher during the first 30 days (HR 1.60; 95%CI 1.30-1.96), but continued to follow a less pronounced linear trend after the peri-procedural period up to one-year of follow-up (HR 1.15; 95%CI 1.01-1.30) (p for interaction 0.26). (**Central Illustration**) At one-year of follow-up, rates of all-cause death (**Supplemental Figure 1**, HR_{adj} 1.12; 95%CI 1.00-1.24), cardiovascular mortality (HR_{adj} 1.20; 95%CI 1.05-1.37) and cerebrovascular events (HR_{adj} 1.21; 95%CI 1.02-1.45) continued to follow the statistical linear trend across age groups.

Observed mortality rates of the SwissTAVI patient cohort were compared to the expected rate of mortality in an age and sex matched national reference population. Of note, SMRs were significantly higher for patients <70 years of age (SMR 12.63; 95%CI 9.06-17.58), patients between 70 and 79 years of age (SMR 4.09; 95%CI 3.56-4.71) and patients between 80 and 89 years of age (SMR 1.63; 95%CI 1.50-1.78), whereas no significant difference was observed for

patients above the age of 90 years (SMR 0.93; 95%CI 0.76-1.14). (**Central Illustration**) This effect was independent of sex and year of treatment. (**Supplemental Figure 2**)

DISCUSSION

The salient findings of this analysis from the SwissTAVI cohort study investigating age-related outcomes after TAVR can be summarized as follows:

(1) More than two thirds of patients undergoing TAVR in Switzerland are older than 80 years of age.
(2) Increasing age is associated with a linear trend for all-cause mortality, stroke and pacemaker implantation during the peri-procedural and longer-term follow-up period after TAVR
(3) Standardized mortality ratios were higher for TAVR patients below the age of 90 years when compared to expected rates of mortality in an age and sex-matched Swiss population.
(4) After 90 years of age patients with valvular heart disease undergoing TAVR had similar rates of mortality than the national reference population.

The present study illustrates real world clinical practice among patients undergoing TAVR in Switzerland and informs on age distribution and associated outcomes. In Switzerland, the majority of TAVR candidates were between 70 years and 90 years of age. While it was somehow expected that only very selected patients (4.6%) receive TAVR below the age of 70 years, it was surprising that only 7.1% of patients were 90 years of age or older. The low rate of nonagenarians undergoing TAVR in this Swiss national study is in contrast to previous reports, as 15.4% and 15.7% of TAVR patients from the national France-2 and the STS / ACC

TVT Registry exceeded 90 years of age, respectively.(8,9) Whether this observation is based on a bigger proportion of patients undergoing TAVR below the age of 90 years, or related to a true restriction of patient access to treatment based on advanced age, cannot be determined with the available dataset. As TAVR is a well-accepted treatment and alternative to surgical aortic valve replacement in Switzerland,(13) a national restrictive approach or a more conservative treatment strategy based on age considerations alone is rather unlikely and mirrors current guideline recommendations. Indeed, neither the European Society of Cardiology nor the American College of Cardiology/American Heart Association provide an upper limit in their age – based recommendations for treatment decision in their most recent guideline document.(14,15)

While advanced age is one of the most convincing decision criteria for TAVR during Heart Team discussion, patient comorbidities and an increased surgical risk is even more relevant for the decision to perform TAVR in younger patients. That younger age does not necessarily mean low surgical risk is illustrated in Table 1 with the description of the baseline clinical characteristics of this patient population. Indeed, TAVR patients below 70 years of age had higher rates of diabetes, dyslipidemia, peripheral artery disease, chronic obstructive pulmonary disease and previous myocardial infarction and cardiac surgery than older patient groups. Moreover, although the estimated risk of mortality in our youngest patient group might indicate low-surgical risk (mean age 64.6±5.8; STS PROM 3.5±4.1), STS scores of a true low-risk patient population from the pivotal PARTNER 3 (mean age 73.3±5.8; STS PROM 1.9±0.7), and EVOLUT low-risk (mean age 74.1±5.8; STS PROM 1.9±0.7) trials had almost half the risk. (16,17)

This SwissTAVI analysis shows an association between increasing age and clinical

outcomes with a linear trend and increasing rates of all-cause and cardiovascular mortality, cerebrovascular events and pacemaker implantation across the pre-specified age groups during 30 day and 1-year follow-up. The observed difference in all-cause mortality across age groups was more pronounced during the peri-procedural phase (0 – 30 days: HR 1.60; 95%CI 1.30-1.96), but continued with a significant trend thereafter up to one year (31 – 365 days: HR 1.15; 95%CI 1.01-1.30) during land-mark analyses (**Central Illustration**). Previous results from single center studies and the France-2 TAVR Registry did not find significant differences in clinical outcomes between octogenarians and nonagenarians,(6-8) whereas the increased risk of mortality observed in the SwissTAVI patient population is in line with the findings of the STS / ACC TVT Registry (rates of mortality at 30 days: 8.8%; and 12 months: 24.8%).(9) More recently, a systematic review and meta-analysis of the observational literature has pointed to the increased risk of mortality in nonagenarians when compared with younger TAVR patients at 30-days (OR 1.73; 95%CI 1.49 - 2.00) and 1-year follow-up (OR 1.39; 95%CI 1.26 - 1.53).(18) Furthermore, our data show an increased risk for cerebrovascular events with a significant linear trend across age groups. This finding corroborates the results of the mentioned meta-analysis, which informs on an increased risk of cerebrovascular accidents in the very elderly patient group (OR 1.32; 95%CI 1.08-1.62). While the STS / ACC TVT Registry and this meta-analysis point towards an increased risk of vascular access site and bleeding complications in nonagenarians, SwissTAVI patients had no significant increase in peri-procedural bleeding or access related complications across age groups. Significant variation in procedural characteristics and device type utilization might be responsible for the observed difference in access site and bleeding complications between studies and the observed difference in permanent pacemaker requirements across age groups. Indeed, elderly patients in SwissTAVI had higher rates of permanent pacemaker implantation when compared with younger

patients. Whether this observation is related to pre-existing conduction disturbances, differences in procedural characteristics (more balloon valvuloplasty) or the more frequent use of self-expanding valve technology in nonagenarians, cannot be answered with this dataset and requires further studies.

In order to evaluate the deleterious effect of valvular heart disease and more specifically aortic stenosis, we compared observed rates of mortality after TAVR to expected rates of mortality in an age- and sex-matched Swiss general population (**Central Illustration**) by using SMRs. Valvular heart disease and associated comorbidities were associated with a significant increase in mortality at one-year for TAVR patients below the age of 90 years compared with the general population, following a significant trend across age groups. Interestingly, patients above the age of 90 years had similar outcomes (SMR 0.93; 95%CI 0.76-1.14) and TAVR was able to restore life expectancy in this patient population when compared with the general population.

Limitations

The results of the present study should be interpreted in light of the following limitation: Firstly, the SwissTAVI Registry is a national, multicenter cohort study and differences in institutional practice for patient selection, procedural performance and in-hospital protocols after TAVR might impact treatment and clinical outcomes of patients. However, this analysis reflects routine clinical practice with standard TAVR procedures utilizing CE – approved devices in Switzerland. Secondly, the present dataset is limited to the variables collected in the general case report forms of SwissTAVI and detailed information on coronary revascularization requirements before or after TAVR, pre-existing conduction disturbances, depth of TAVR prosthesis within the left ventricular outflow tract and other important

variables, previously identified as independent predictors of permanent pacemaker implantation after TAVR, are missing. Furthermore, the risk assessment in SwissTAVI is limited to traditional risk scores, and detailed information on frailty parameters, specific medical or anatomical conditions that might influence the Heart Team decision towards TAVR, are missing. Thirdly, the SwissTAVI cohort study is a national instrument for quality assessment after transcatheter heart valve intervention rather than a disease specific registry. Therefore, a bias of positive patient selection, particularly in the group of nonagenarians, needs to be considered before interpreting the data.

Conclusions

Increasing age is associated with a linear trend for mortality, stroke and pacemaker implantation among patients undergoing TAVR. While younger patients undergoing TAVR were at increased risk of mortality when compared with expected rates of mortality from the general Swiss population, we found no differences in mortality among patients aged ≥90 years.

CLINICAL PERSPECTIVES

What is known? Transcatheter aortic valve replacement (TAVR) has emerged as the preferred treatment modality for a broad spectrum of elderly patients with symptomatic, severe aortic stenosis. However, the available literature provides conflicting evidence about the clinical benefit of TAVR in the very elderly patient population.

What is new? Increasing age is associated with a linear trend for all-cause mortality, stroke and pacemaker implantation during the peri-procedural and longer-term follow-up period after TAVR. After 90 years of age, patients with valvular heart disease undergoing TAVR had similar rates of mortality when compared with the national reference population.

What is next? Prospective studies are required to determine the prognostic value of TAVR in the very elderly patient population and inform on benefits in health-related quality of life in this patient population.

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FIGURE LEGENDS

Central Illustration – Rates of all-cause mortality across age groups including land-mark analysis after the peri-procedural period (left panel). Standardized mortality ratios (SMRs) to compare trends in mortality of TAVR patients with an age- and sex-matched Swiss general population during the respective year of treatment (downloaded from the Swiss Federal Office for Statistics - Bundesamt für Statistik, Switzerland) (right panel)

TABLE 1. BASELINE CLINICAL CHARACTERISTICS

	ALL PATIENTS N = 7097	AGE GROUPS (YEARS) <70 N = 324	70-79 N = 1913	80-89 N = 4353	≥90 N = 507	P-VALUE
Age (years)	82.0 ± 6.4	64.6 ± 5.8	76.5 ± 2.6	84.5 ± 2.7	92.0 ± 1.7	<0.001
Female sex	3519 (49.6%)	111 (34.3%)	807 (42.2%)	2301 (52.9%)	300 (59.2%)	<0.001
Body mass index (kg/cm²)	26.7 ± 5.1	28.3 ± 6.9	28.1 ± 5.7	26.3 ± 4.5	24.3 ± 4.0	<0.001
Cardiac Risk Factors						
Diabetes mellitus	1819 (25.6%)	113 (34.9%)	618 (32.3%)	1031 (23.7%)	57 (11.2%)	<0.001
Dyslipidemia	3721 (52.5%)	186 (57.4%)	1101 (57.6%)	2237 (51.4%)	197 (38.9%)	<0.001
Art. Hypertension	5598 (78.9%)	228 (70.4%)	1556 (81.4%)	3430 (78.8%)	384 (75.7%)	<0.001
Past Medical History						
Previous pacemaker implantation	687 (9.7%)	34 (10.5%)	144 (7.5%)	435 (10.0%)	74 (14.6%)	<0.001
History of myocardial infarction	937 (13.2%)	49 (15.1%)	277 (14.5%)	555 (12.7%)	56 (11.0%)	0.085
History of cardiac surgery	1002 (14.1%)	90 (27.8%)	367 (19.2%)	493 (11.3%)	52 (10.3%)	<0.001
History of cerebrovascular accident	835 (11.8%)	34 (10.5%)	234 (12.2%)	495 (11.4%)	72 (14.2%)	0.22
Clinical Features						
Peripheral artery disease	1158 (16.3%)	65 (20.1%)	357 (18.7%)	660 (15.2%)	76 (15.0%)	0.001
COPD	846 (11.9%)	67 (20.7%)	311 (16.3%)	438 (10.1%)	30 (5.9%)	<0.001
Coronary artery disease	4086 (57.6%)	163 (50.5%)	1118 (58.4%)	2517 (57.8%)	288 (56.8%)	0.057
LVEF (%)	55.4 ± 14.0	50.5 ± 16.9	55.1 ± 14.6	56.0 ± 13.5	54.5 ± 13.0	<0.001
Aortic valve area (cm²)	0.72 ± 0.25	0.80 ± 0.27	0.75 ± 0.25	0.71 ± 0.24	0.63 ± 0.21	<0.001
Mean gradient (mmHg)	42.2 ± 18.2	39.3 ± 18.3	41.7 ± 17.8	42.5 ± 18.3	44.1 ± 19.2	0.001
Symptoms on admission						
NYHA functional class						
III or IV	4294 (62.2%)	185 (58.4%)	1123 (59.9%)	2653 (63.0%)	333 (66.9%)	0.008
Risk Assessment						
STS – PROM	5.2 ± 4.1	3.5 ± 4.1	4.0 ± 3.7	5.6 ± 4.0	8.2 ± 4.7	<0.001

Depicted are counts (%) or means with standard deviations (±SD)

TABLE 2. PROCEDURAL CHARACTERISTICS

	ALL PATIENTS N = 7097	AGE GROUPS (YEARS) <70 N = 324	70-79 N = 1913	80-89 N = 4353	≥90 N = 507	P VALUE
Procedure time (min)	69.5 ± 39.5	68.8 ± 42.4	68.9 ± 37.8	69.6 ± 40.3	71.2 ± 37.3	0.75
Total contrast administered (cc)	161.7 ± 94.9	147.9 ± 88.8	159.3 ± 96.0	163.8 ± 94.7	160.8 ± 95.3	0.056
Main access site						**0.001**
Femoral	6403 (90.2%)	285 (88.0%)	1704 (89.1%)	3940 (90.5%)	474 (93.5%)	
Transapical	509 (7.2%)	25 (7.7%)	154 (8.1%)	308 (7.1%)	22 (4.3%)	
Subclavian	68 (1.0%)	10 (3.1%)	22 (1.2%)	36 (0.8%)	0 (0.0%)	
Direct aortic	59 (0.8%)	3 (0.9%)	17 (0.9%)	34 (0.8%)	5 (1.0%)	
Other	58 (0.8%)	1 (0.3%)	16 (0.8%)	35 (0.8%)	6 (1.2%)	
Device Features						
Balloon valvuloplasty	4496 (63.4%)	176 (54.3%)	1160 (60.6%)	2807 (64.5%)	353 (69.6%)	<0.001
Device						<0.001
Medtronic CoreValve	922 (13.0%)	47 (14.6%)	207 (10.9%)	581 (13.4%)	87 (17.2%)	0.001
Medtronic Evolut R	1123 (15.9%)	51 (15.8%)	287 (15.0%)	694 (16.0%)	91 (18.0%)	0.44
Evolut PRO	219 (3.1%)	9 (2.8%)	62 (3.3%)	122 (2.8%)	26 (5.1%)	0.037
Edwards Sapien THV / XT	606 (8.6%)	28 (8.7%)	150 (7.9%)	381 (8.8%)	47 (9.3%)	0.62
Edwards Sapien 3	2712 (38.3%)	123 (38.1%)	793 (41.6%)	1625 (37.4%)	171 (33.8%)	0.002
BSC Lotus	301 (4.3%)	13 (4.0%)	60 (3.1%)	206 (4.7%)	22 (4.3%)	0.039
BSC Lotus Edge	9 (0.1%)	0 (0.0%)	2 (0.1%)	7 (0.2%)	0 (0.0%)	0.68
BSC Symetis Acurate / - NEO	590 (8.3%)	18 (5.6%)	167 (8.8%)	375 (8.6%)	30 (5.9%)	0.046
JenaValve	59 (0.8%)	2 (0.6%)	18 (0.9%)	38 (0.9%)	1 (0.2%)	0.39
Abbott / SJM Portico	470 (6.6%)	24 (7.4%)	142 (7.4%)	279 (6.4%)	25 (4.9%)	0.17
Direct Flow Medical	42 (0.6%)	5 (1.5%)	9 (0.5%)	24 (0.6%)	4 (0.8%)	0.115
Allegra NVT	24 (0.3%)	3 (0.9%)	10 (0.5%)	9 (0.2%)	2 (0.4%)	0.056
Medtronic Engager	2 (0.0%)	0 (0.0%)	0 (0.0%)	2 (0.0%)	0 (0.0%)	0.74
Aortic regurgitation at discharge						0.006
none	3004 (43.2%)	145 (45.9%)	858 (45.8%)	1812 (42.4%)	189 (38.3%)	
mild	3669 (52.7%)	159 (50.3%)	959 (51.2%)	2277 (53.3%)	274 (55.5%)	
moderate	262 (3.8%)	10 (3.2%)	50 (2.7%)	173 (4.0%)	29 (5.9%)	
severe	22 (0.3%)	2 (0.6%)	5 (0.3%)	13 (0.3%)	2 (0.4%)	

Depicted are counts (%) or means with standard deviations (±SD) or medians with interquartile ranges (25%; 75%)

TABLE 3. IN-HOSPITAL COURSE

	ALL PATIENTS N = 7097	AGE GROUPS (YEARS) <70 N = 324	70-79 N = 1913	80-89 N = 4353	≥90 N = 507	P VALUE
Packed Red Blood Cells (PRBC) transfusion	969 (13.7%)	38 (11.7%)	241 (12.6%)	616 (14.2%)	74 (14.7%)	0.24
Total number of PRBC	2.0 (1.0; 3.0)	2.0 (2.0; 7.0)	2.0 (1.0; 3.0)	2.0 (1.0; 3.0)	2.0 (1.0; 3.0)	0.017
Overall In-Hospital Stay (days)	9.5 ± 6.0	10.0 ± 7.6	9.3 ± 6.4	9.6 ± 5.7	10.0 ± 5.8	0.02
Intensive care unit	1.2 ± 2.3	1.2 ± 3.2	1.2 ± 2.5	1.2 ± 2.2	1.0 ± 1.9	0.44
Intermediate care	1.6 ± 2.3	2.0 ± 2.3	1.5 ± 2.2	1.6 ± 2.3	1.6 ± 2.2	0.024
General ward	6.8 ± 5.2	6.9 ± 6.7	6.5 ± 5.5	6.8 ± 4.9	7.5 ± 5.7	0.002
Hospital discharge						<0.001
home	3067 (43.3%)	179 (55.4%)	987 (51.6%)	1751 (40.3%)	150 (29.6%)	
referring hospital	824 (11.6%)	31 (9.6%)	184 (9.6%)	518 (11.9%)	91 (18.0%)	
rehabilitation clinic	2772 (39.1%)	94 (29.1%)	664 (34.7%)	1811 (41.7%)	203 (40.1%)	
nursing home	177 (2.5%)	7 (2.2%)	32 (1.7%)	106 (2.4%)	32 (6.3%)	
other	242 (3.4%)	12 (3.7%)	44 (2.3%)	156 (3.6%)	30 (5.9%)	

Depicted are counts (%) or means with standard deviations (±SD) or medians with interquartile ranges (25%; 75%)

TABLE 4. CLINICAL OUTCOMES AT 30 DAYS AND 1 YEAR OF FOLLOW-UP

		AGE GROUPS (YEARS)				LINEAR TREND HAZARD RATIOS [95% CI]			
	ALL PATIENTS	<70	70-79	80-89	≥90	HR [95% CI]	P-VALUE	ADJ.HR [95% CI]	ADJ.P-VALUE
	N = 7097	N = 324	N = 1913	N = 4353	N = 507				
At 30 days									
Mortality	243 (3.4)	10 (3.1)	39 (2.0)	160 (3.7)	34 (6.7)	1.59 (1.30-1.96)	<0.001	1.45 (1.18-1.77)	<0.001
Cardiovascular Mortality	216 (3.1)	7 (2.2)	36 (1.9)	141 (3.3)	32 (6.3)	1.68 (1.35-2.09)	<0.001	1.53 (1.23-1.91)	<0.001
Cerebrovascular Accident	233 (3.3)	6 (1.9)	47 (2.5)	157 (3.6)	23 (4.6)	1.40 (1.14-1.72)	0.001	1.35 (1.09-1.66)	0.005
Disabling Stroke	127 (1.8)	2 (0.6)	23 (1.2)	88 (2.0)	14 (2.8)	1.60 (1.20-2.12)	0.001	1.53 (1.14-2.04)	0.004
Myocardial Infarction	43 (0.6)	3 (0.9)	14 (0.7)	25 (0.6)	1 (0.2)	0.72 (0.47-1.11)	0.14	0.71 (0.46-1.10)	0.13
Peri-procedural MI	34 (0.5)	1 (0.3)	12 (0.6)	20 (0.5)	1 (0.2)	0.82 (0.50-1.33)	0.42	0.83 (0.50-1.37)	0.46
Spontaneous MI	9 (0.1)	2 (0.6)	2 (0.1)	5 (0.1)	0 (0.0)	0.47 (0.20-1.14)	0.094	0.44 (0.18-1.07)	0.070
Acute Kidney Injury – Stage 3	104 (1.5)	12 (3.7)	32 (1.7)	55 (1.3)	5 (1.0)	0.65 (0.50-0.86)	0.002	0.60 (0.46-0.78)	<0.001
Bleeding	1266 (17.9)	59 (18.3)	311 (16.3)	807 (18.6)	89 (17.7)	1.06 (0.97-1.15)	0.17	1.02 (0.94-1.11)	0.61
LT or Major Bleeding	907 (12.8)	39 (12.1)	219 (11.5)	586 (13.5)	63 (12.5)	1.09 (0.98-1.20)	0.103	1.04 (0.94-1.15)	0.48
Access Related Complications	1147 (16.2)	41 (12.7)	291 (15.2)	730 (16.8)	85 (16.8)	1.10 (1.01-1.21)	0.027	1.07 (0.97-1.17)	0.17
Major Complication	696 (9.8)	24 (7.4)	174 (9.1)	449 (10.3)	49 (9.7)	1.11 (0.99-1.24)	0.077	1.07 (0.95-1.20)	0.27
Pacemaker implantation	1185 (16.9)	35 (10.9)	278 (14.6)	772 (18.0)	100 (20.0)	1.24 (1.14-1.36)	<0.001	1.23 (1.12-1.34)	<0.001
At 1 Year									
Mortality	838 (12.2)	35 (11.2)	194 (10.6)	512 (12.1)	97 (19.7)	1.26 (1.13-1.40)	<0.001	1.12 (1.00-1.24)	0.041
Cardiovascular Mortality	573 (8.4)	23 (7.5)	126 (6.9)	350 (8.4)	74 (15.3)	1.35 (1.18-1.54)	<0.001	1.20 (1.05-1.37)	0.006
Cerebrovascular Accident	329 (4.8)	9 (2.9)	80 (4.4)	208 (5.0)	32 (6.7)	1.25 (1.06-1.48)	0.009	1.21 (1.02-1.45)	0.029
Disabling Stroke	177 (2.6)	4 (1.4)	43 (2.4)	112 (2.7)	18 (3.7)	1.29 (1.03-1.63)	0.030	1.25 (0.99-1.59)	0.066
Myocardial Infarction	82 (1.2)	4 (1.3)	25 (1.4)	49 (1.2)	4 (1.0)	0.87 (0.64-1.20)	0.41	0.87 (0.62-1.20)	0.39
Spontaneous MI	48 (0.8)	3 (1.0)	13 (0.8)	29 (0.8)	3 (0.8)	0.92 (0.60-1.40)	0.70	0.89 (0.58-1.38)	0.62
Bleeding	1436 (20.6)	67 (21.0)	362 (19.2)	905 (21.1)	102 (20.8)	1.05 (0.97-1.13)	0.23	1.01 (0.93-1.09)	0.86
LT or Major Bleeding	1038 (14.9)	43 (13.4)	251 (13.3)	670 (15.6)	74 (15.1)	1.10 (1.00-1.21)	0.043	1.05 (0.95-1.15)	0.33
Pacemaker implantation	1289 (18.6)	44 (13.9)	308 (16.4)	830 (19.5)	107 (21.7)	1.20 (1.11-1.31)	<0.001	1.19 (1.09-1.30)	<0.001

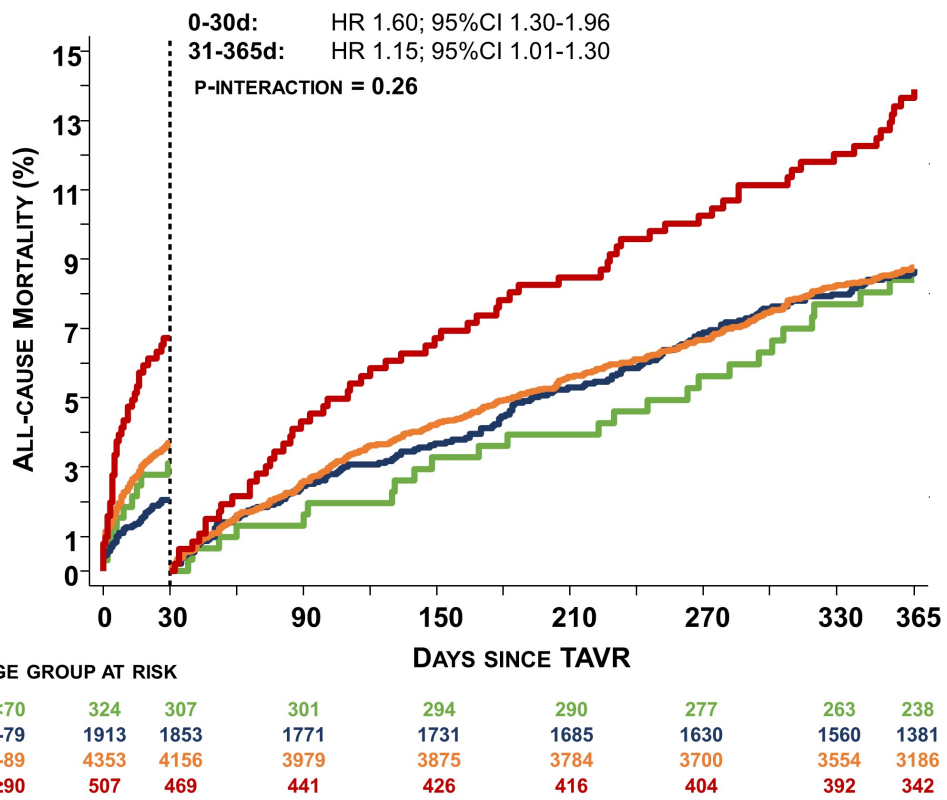
Depicted are nr of event (% from lifetable estimate), only first event of each type counted per patient; Adjusted hazard ratio: adjusted for STS PROM score, femoral access vs other access and year of procedure
LT… life-threatening

CENTRAL ILLUSTRATION

CENTRAL ILLUSTRATION — AGE AND OUTCOMES AFTER TAVR

SWISSTAVI REGISTRY

7,097 consecutive patients undergoing TAVR at 15 heart valve centers in Switzerland



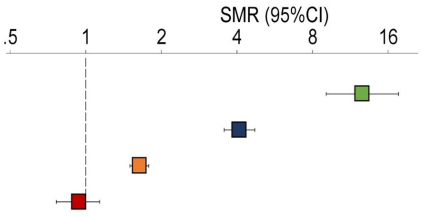
AGE GROUP AT RISK

<70	324	307	301	294	290	277	263	238
70-79	1913	1853	1771	1731	1685	1630	1560	1381
80-89	4353	4156	3979	3875	3784	3700	3554	3186
≥90	507	469	441	426	416	404	392	342

CLINICAL OUTCOMES

TRENDS IN MORTALITY OF TAVR PATIENTS WITH AN AGE- AND SEX-MATCHED SWISS GENERAL POPULATION DURING THE RESPECTIVE YEAR OF TREATMENT

AGE GROUP	DEATHS / NR OF PATIENTS	SMR (95% CI)
<70	35/324	12.63 (9.06-17.58)
70-79	194/1913	4.09 (3.56-4.71)
80-89	512/4353	1.63 (1.50-1.78)
≥90	97/507	0.93 (0.76-1.14)



- Increasing age is associated with a linear trend for all-cause mortality, stroke and pacemaker implantation during the peri-procedural and longer-term follow-up period after TAVR.
- Standardized mortality ratios were higher for TAVR patients below the age of 90 years when compared to expected rates of mortality in an age and sex-matched Swiss population.